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Hydrogen Sulfide Removal by Biological Methods

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Executive Summary

The objectives of this Study are to review different biological odor removal technologies and to evaluate the possibilities of applying a variety of such technologies in the sewage treatment works in Hong Kong. A desktop study of biological odor removal technologies had been carried out through review of literature and commercially available products. Biofilter (BF) and biotrickling filters (BTF) are the focuses. Performances of selected BTFs in DSD were shown.

Biological odor treatment technologies are applicable for a wide range of pollutants including hydrogen sulfide (H_2S) gas. Biological technologies for example bioscrubber is more suitable for H_2S removal in energy gas. BF and BTF technologies can be used under ambient pressure, and temperature, and are not energy- nor resource-intensive, and simple to operate. Generally speaking, biological H_2S treatment by BF and BTF is considered environmental friendly because less chemical is consumed when compared to chemical scrubber and impregnated activated carbon. Biological H_2S treatment does not generate secondary pollutants such as NO_x or wasted activated carbon. As a green technology, it can be well received by the general public.

When compared to other odor abatement technologies including physical-chemical and combustion, biological H_2S treatment with BF and BTF possess benefits of low operation cost and low maintenance. At moderate H_2S level, a study compared various odor abatement technologies found the operating cost is the lowest for BTF and followed closely by BF.

Treatment capability of H_2S can be expressed in Elimination Capacity (EC) in $gH_2S/m^3.h$. Important design considerations are empty bed residence time (EBRT), inlet H_2S level, EC and required removal efficiency (RE). Longer EBRT means a larger media bed for the deodorizing unit and therefore a larger footprint. At higher inlet H_2S, the use of a biological system with a higher EC for the same RE can result in a smaller unit.

The most noticeable disadvantages of biological H_2S treatment (both BF & BTF) are acclimation period required, limited ability to handle shock loads, subject to short circuiting and upsets, the low pH in blowdown. They may also require a final polishing step to meet very stringent exhaust air standard. A combined BTF+Activated carbon (BTF+AC) has been reported to achieve very high robustness in odor removal, but its operating cost will be significantly higher than a BTF-only system. A combined BTF+AC therefore becomes particularly desirable in the presence of sensitive neighbors.

In addition to engineered BF systems, open-bed type BF with very simple design had been installed in various sewage treatment facilities. They typically used low-cost tree-bark as the packing media. The outcome was perceived to be positive when the tree-bark media can be kept moist throughout the operation.

In design, the permissible inlet H_2S for BTF is generally higher than BF, BF could be selected when average is about ≥10ppmv[1], and BTF for average H_2S ≥20ppmv. In order to achieve similar H_2S removal, the required EBRT of BF is longer than that of BTF. Though a higher H_2S removal capacity is expected from a larger system (longer EBRT), there is no simple rule. A large fraction of BTF systems in DSD for average inlet H_2S of 20 ppmv, EBRT of 12-15 sec has been adopted. BF can have EBRT of 30 sec or more.

When the inlet level is high (>50ppmv), EC is more important. Shatin STW inlet works (DO#1) BTF with design average H_2S 20 ppmv, using biocoal as packing media, demonstrated remarkably good RE at average H_2S 60 ppmv and achieved EC of 15 $gH_2S/m^3.h$.

For the treatment of exceptionally high inlet H_2S (e.g. 3000ppmv), a BTF with ordinary packaging media will be enormous in size. BioAir Solutions LLC reported their proprietary structured packing media EcoBase™ can deliver a very high EC (for RE 99%, the EC is about $100gH_2S/m^3.h$). The system would be designed to operate with the foul air diluted to 500ppmv H_2S level for biological treatment.

On the other hand, performance reports of biological treatment of low inlet H_2S level (<5ppmv) by BF or BTF were scarce in literature. In these cases, high EC is not a concern and EBRT becomes the limiting factor. Though EBRT as short as 2 sec had been reported in laboratory- and pilot-scale studies, such extreme EBRT is rare in full-scale operation.

Acclimation of biomass is important for the performance of biological H_2S treatment. They are reportedly not particularly capable of treating infrequent H_2S peaks or shock loads. Nonetheless, Ma Wan STW (DO#3) BTF using synthetic polypropylene (PP) as packing media demonstrated high RE of transient H_2S peaks (up to 60ppmv) which was 5 times the average level or 3 times the design average H_2S.

Biological H_2S treatment in Hong Kong has been tested to be positive. Good performances of BTF were apparent both in cases of treating consistent high-H_2S (using biocoal as packing media) and removal of H_2S peaks (using PP). However, there had been few data of BF treating H_2S at relatively high level. Due to longer EBRT and limit of bed

[1] ppmv is Parts per million by volume. For any gas, 100% is 1,000,000 ppmv. For example, 1% H_2S gas is 10,000 ppmv. The relation between mg/m^3 and ppmv depends on the Molecular weight (MW) of the gas. For H_2S gas, at standard condition, 1 ppmv H_2S is about 1.4 mg H_2S/m^3.

depth for BF, the land use requirement of BF is generally higher. Further, BTF is likely to be more capable of handling higher inlet H_2S concentration. For BF, there is a concern of its lack of operational control. As a result, BTF is normally preferred when design average inlet H_2S is 20ppmv or above.

Based on the findings of this desktop study, it is recommended to continue the use of biological H_2S treatment unless the inlet H_2S is very low for which activated carbon filter may suffice. When the average is at or above 20ppmv, BTF is favored over BF.

A combined BTF+AC system can provide higher robustness than a BTF-only system. It can be recommended when the exhaust air is close to sensitive neighbors. The operating cost of the combined system will be higher than BTF-only.

Retrofitting of wet-scrubber using caustic (NaOH) and bleach solution to BTF has been reported and they have been reported to give successful and very positive H_2S treatment performance. Due to the low operating cost of BTF when compared to the high chemical cost for chemical scrubber, the possibility of similar retrofitting work can be explored.